WEST AFRICAN CACAO RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 36

TAFO, GOLD COAST.

COMMONWEALTH MYCOLOGICAL
9 MAR 1955

WEST AFRICAN CACAO RESEARCH INSTITUTE
TAFO

THIRTY-SIXTH QUARTERLY REPORT : OCTOBER-DECEMBER, 1954.

SENIOR STAFF

Director	:	(vacant)
Deputy Director	:	A. Pickles (Acting Director)
Maintenance Engineer	:	C. Alderson, D.S.O.
Secretary	:	G. H. Neal

TAFO STATION

Division of Entomology	:	H. R. Mapother F. Raw (arrived 26th November) D. J. Taylor P. B. Cornwell F. E. Decker
Division of Pathology		W. T. Dale T. W. Tinsley A. L. Wharton G. Usher
Division of Botany	:	J. F. Archibald H. H. Rogers R. Knight A. D. McKelvie (on leave 8th December)
Division of Soil Science and Chemistry	:	S. N. Adams Miss E.M. Holden (arrived 19th October)
Division of Agronomy	:	R. J. Benstead R. Wickens
Station Manager	:	S. E. N. Kwafo

IBADAN SUB-STATION

Acting Officer-in-charge	:	J. Nicol
Entomologist	:	R. G. Donald
Pathologists	:	R. M. Lister J. M. Thresh

STAFF .../

STAFF MATTERS

The post of Director, vacant since the 6th August, 1954, has been offered to and accepted by Mr. J. Lamb, O.B.E., Director of the Tea Research Institute of Ceylon. It is understood that Mr. Lamb will assume his new duties about October 1955.

Mr. J. Nicol, Senior Entomologist, has been posted to Ibadan as acting officer-in-charge of the Institute's sub-station there. Thanks are due to Dr. J. M. Waterston, who undertook the business administration of the sub-station from the time of its inception until Mr. Nicol took over this duty from him, for his most valuable help during this period.

The Director of Rothamsted Experimental Station has again rendered valuable assistance to the Institute by releasing two of his research workers on secondment to the Institute. Miss E. M. Holden, Biochemist, assumed duty for two tours on the 19th October; she will work on biochemical aspects of virus problems. Dr. F. Raw, Entomologist, arrived on the 26th November for one tour during which he will specialise on capsid investigations.

MANAGING COMMITTEE

The Managing Committee met at Tafo for its fifteenth meeting on the 10th and 11th November, 1954. Members attending for the first time in that capacity were Messrs. B. E. Dwira and E. A. Haizel (Gold Coast) and Messrs. H. H. Croucher, R. W. Ellison and J. M. Waterston (Nigeria). This meeting was preceded by a meeting of the Technical Sub-Committee on the 9th November.

VISITORS

The number of visitors to the Institute remained at a high level and included the Honourable J. E. Jantuah, Gold Coast Minister of Agriculture, Sir Hilton Poynton and Mr. Adrian Cadbury, in addition to representatives of cocoa and chocolate manufacturers from the United Kingdom and the United States of America, representatives of chemical and insecticide manufacturers and Government officials from Nigeria, the Gold Coast and the United Kingdom, including officers of Departments of Agriculture. The Ibadan Sub-Station has also received its share of visitors.

MANAGEMENT AND MAINTENANCE

It has been necessary to resume construction work at Tafo to accommodate additional senior staff and to provide accommodation for visitors. A new bungalow and a capsid research laboratory are in course of construction and an extension is being made to the Rest House to provide two additional rooms.

At Ibadan, a store building has been commenced and it is hoped that contracts for the new laboratory building there will shortly be let.

The .../

The water supply at Tafo remained satisfactory throughout the quarter and weekly tests invariably showed complete absence of contamination. With the advent of dry weather, consumption increased markedly and exceeded 30,000 gallons on two days in December. Much of this increase is due to the use of the standpipes by people from Tafo town.

CROP DELIVERY

The total harvest to date at the Tafo Station is 9.5 per cent. below that of the corresponding period of last year, which was itself below average. The incidence of black pod disease was slightly higher than last year.

SWOLLEN SHOOT DISEASE

The incidence of swollen shoot disease at Tafo and at the out-stations is shown in the following table, which gives the number of infected trees discovered.

	Oct.	Nov.	Dec.	Total
Old Station	32	38	18	88
Square Mile	82	123	85	290
Adonkwanta	22	12	-	34
Akwadum	-	2	1	3
Nankese	-	-	-	-
Kukua	2	2	-	4
Koransang	1	-	-	1

ROUTINE CAPSID CONTROL

At the main station at Tafo, capsid control measures on all maintained cacao areas have been adopted. Spray painting has been practised in cases where the trees are too tall for hand painting.

OUT-STATIONS

Routine shade reduction has been continued at all out-stations and it is considered that an optimum condition has been reached.

There was a heavy flowering on the trees on the drier stations at Nankese, Kukua and Koransang, following heavy rains in October, and although there has been a good "set" it is doubtful if many of the pods will mature.

Capsid damage has not been severe and has been confined to the less well-shaded areas.

IMPROVED PLANTING MATERIAL

A total of 4,694 pods of the Upper Amazon selections T60, 63, 85 and 87 have been supplied to the Gold Coast Department of Agriculture from the Upper Amazon Spacing

Experiment .../

Experiment and the adjoining Multiplication Plot. The seeds are employed by the Department to stock nurseries from which seedlings will be issued to farmers in 1955.

In addition, 500 pods of "approved" Upper Amazon types have been supplied to the Department of Agriculture of Western Nigeria.

RAINFALL

The monthly rainfall for the quarter at each of the Institute's observation stations in the Gold Coast is given in the following table.

Station	Rainfall in ins				Wet days			
	Oct.	Nov.	Dec.	Total	Oct.	Nov.	Dec.	Total
Tafo	8.92	1.75	1.45	12.12	21	11	6	38
" (16-yr. mean)	8.67	4.87	2.38	15.92	18	11	5	34
Adonkwanta	8.89	4.06	1.18	14.13	11	8	4	23
Akwadum	7.68	2.78	1.20	11.66	21	7	5	33
Nankese	10.49	3.76	2.43	16.68	14	5	5	24
Kukua	7.71	3.13	1.36	12.20	10	8	3	21
Koransang	9.65	3.38	1.64	14.67	11	8	4	23

RESEARCH WORK

The brief reports on research work during the quarter which follow have been arranged in the order set out in the approved research programme. The reports of the Tafo Station and those of the Ibadan Sub-Station are given separately.

TAFO STATION

1. VIRUS RESEARCH

(a) Host Range of Cacao Viruses

A total of eleven trees of Adansonia digitata L. have been found naturally infected to date with a virus that can be transmitted to cacao. Nine of these occur on the Accra Plains and two in the Northern Territories, at Wasipe and Yabrasu, many miles from the nearest cacao farms. The trees seem to be infected with a complex of strains which produce dissimilar symptoms in cacao.

The survey of the distribution of Cola chlamydantha K. Schum., which is being made in collaboration with the Gold Coast Department of Agriculture, is almost complete.

Bombax malabaricum, a native of Ceylon and India, has been artificially infected with the New Juaben strain of cacao swollen shoot virus. Corchorus trilocularis L., a native herb, has proved susceptible to at least six strains.

(b) .../

(b) Optimum Conditions for Transmission

Two further experiments have been completed to elucidate the effect of test-feeding time on transmission of the New Juaben strain to dissected cacao beans by young adults of P. njalensis. These confirm the view previously expressed (see thirty-fourth Quarterly Report) that test-feeding times exceeding about 4 hours do not give any further increase in infection rate. When the insects settle quickly the optimum infection rate can be achieved in two hours, and if all could be induced to begin to insert their stylets immediately it would probably be achieved even more quickly. It has been confirmed that vectors transferred directly from source plants to test beans may sometimes infect the latter in as little as 15 minutes.

The results from an experiment to elucidate the effect of infection-feeding time were given in the last Quarterly Report. Although the highest infection rate was obtained after 16 hours, statistical examination of the data suggested a theoretical optimum at almost 24 hours. In a second experiment with infection-feeding periods of 8, 16, 24 and 32 hours the infection rates were 55, 85, 76 and 76% respectively. This suggests that 16 hours infection feeding may give better transmission than 24 or 32 hours. In a third experiment (started before the results of the second were available) periods of 1, 2, 3, 4, 5 and 6 days were compared. As it was expected from the first experiment that there might be a substantial drop in infectivity for longer feeding periods, the number of young adult mealybugs per test bean was increased from two to three; but in fact the infection rates proved to be between 80 and 90 per cent. for all treatments. In practice the use of source-feeding periods exceeding 2 or 3 days is undesirable, as the number of usable mealybugs remaining on the source plants diminishes.

In all experiments such as the above, when vectors were being transferred to test beans after infection feeding, only the ones found to have their stylets inserted in the source plant were used. Inevitably, however, these must have penetrated the plants after varying times; moreover, there is no evidence that mealybugs feed continuously even while the stylets are within the tissues. Though all experimental feeding was carried out in the dark, diurnal or seasonal variations in temperature or humidity may have influenced settling or feeding on either source plants or test beans, thus contributing to differences between the results of the three infection-feeding experiments. In this connection it may be noted that only in the last, by virtue of its time scale, were the insects manipulated at the same times each day.

The experiment to find out the effect of varied preliminary starving on infection rate, using a 16-hour infection-feeding period (see previous Quarterly Report), is now complete. There were no appreciable differences between the treatments, except that 3 hours preliminary starving appeared to give a lower transmission rate (25 per cent.) than either no starving (43 per cent.) or longer starving periods (33-43 per cent.). This may reflect settling behaviour, but is more likely to be fortuitous.

(c) .../

(c) Classification of Viruses and Virus Strains

This work is continuing, and there appears to be good evidence that at least two entirely distinct viruses infect cacao in West Africa. The presence or absence of swellings seems to be an important diagnostic feature. More tests are still required, however, before a system of classification can be put forward.

(e) Effect of Nutrition on Infection

The main treatment effects in the last two water culture experiments (III and IV) undertaken in conjunction with the Soil Chemist are summarized below:-

Infection with the New Juaben strain of swollen shoot virus had a retarding effect on the growth of young seedlings in both experiments. The growth of healthy and diseased plants in different culture solutions showed the same trends. In Experiment III, plants receiving a complete nitrogen (n) phosphorus (P) and potassium (K) treatment grew best, followed successively by those receiving only N and K, N and P, and N alone. Plants in solutions without N were poorly developed after two and a half months. In Experiment IV, the plants received four different levels of N, each with normal P and K. The application of four times the normal N requirement proved toxic and both healthy and diseased plants were killed. Growth with a half normal level of N was slightly retarded, and that with twice normal N was extremely poor.

The experiments indicated a higher level of N, as a percentage of the total dry weight, in infected plants.

No treatment affected the expression of leaf symptoms, when assessed as a ratio between the number of leaves on a plant showing a particular symptom and its total number of leaves.

Both the number and severity of root swellings were reduced in infected plants receiving nitrogen. In Experiment IV there was a progressive reduction in the number of swellings from the low to the high levels of nitrogen.

Two more nutrition experiments are being prepared.

(f) Chemical Detection of Virus Infection

The survey of the W.A.C.R.I. Old Station cacao using the colour test described by Tinsley and Usher (Nature, Lond., 174, p.87) has been discontinued until results are available from the "back-tests" made on a selection of diagnosed trees (see previous Quarterly Report). These results should give an estimate of the limits of accuracy of the test.

Mature trees on the Old Station diagnosed as infected by symptoms were each sampled at about thirty sites. Not all samples from any one tree gave a positive reaction to the test, which suggests that the virus may be incompletely systemic; moreover, out of fifty test seedlings from "back-tests" made two months ago, only one has yet shown symptoms.

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It has been found that if leaves showing necrosis are tested, colours darker than normal are obtained with both healthy and infected material. This may lead to virus-free trees being wrongly diagnosed as infected. Leaves with the mottle caused by zinc deficiency may also give a misleading red colour. On the other hand, the test has given reliable results with leaves that have been dried and pressed as herbarium specimens.

As previous small-scale trials have indicated that erratic results may be obtained with cacao other than Amelonado, larger numbers of supposedly virus-free trees, representing ten of the Trinidad Introductions, have been subjected to the test. Five single-leaf samples were taken per tree, two from opposite sides near the ground, one from each of two sites near the top, and one from the centre of the tree. Individual samples from the same tree often gave a wide range of colours. Results based on bulked samples from each tree are summarized below:-

Clone	Number of trees tested	Number giving +ve reaction	Percentage	Clone	Number of trees tested	Number giving +ve reaction	Percentage
T.60	31	5	16.1	T.76	32	9	28.1
T.63	40	9	22.5	T.79	34	2	5.8
T.65	22	5	22.7	T.82	25	6	24.0
T.72	31	7	22.6	T.85	40	1	2.5
T.73	50	24	48.0	T.87	29	3	10.3

Experiments are in progress to compare the times taken after artificial infection for virus to become detectable (a) by the colour test, (b) by back-tests made with mealybugs and (c) by grafting. Six-month-old Amelonado seedlings infected by the New Juaben, Offa Igbo, Bosumtwe and Bosumuoso strains are being used. An attempt is being made to find out how these times vary with shade and soil moisture, using the New Juaben strain.

So far, it seems that the chemical tests described by Ninomiya and Hino and by Lindner (to which reference was made in the previous Quarterly Report) are less accurate for swollen shoot disease diagnosis than the Tinsley-Usher test. Though the test described by Cornuet is satisfactory for the detection of virus in leaf samples from diseased mature cacao trees, it is even less efficient than the Tinsley-Usher test for diagnosing infection in very young seedlings.

An examination has been commenced of the reactions involved in this test. It has been shown previously that diseased leaves have a higher total "tannin" content than have healthy leaves of the same age. This observation has been confirmed. Extracts of minced healthy and diseased leaves have been found to contain about twenty per cent. of the total "tannin" of the leaves and diseased leaves contain twice or three times as much "tannin" as do healthy leaves.

Some .../

Some progress has been made in identifying the polyphenols present in leaves of both types. Attempts are proceeding to improve the test by clarifying the extracts and by other methods, but these have so far been unsuccessful.

(g) Morbid Histology of Infected Cacao

This study is almost complete and is being written up for publication.

Resistance to the New Juaben Strain of Swollen Shoot Virus

More of the Iquitos plants that were "bombarded" as beans with infective crawlers of Pseudococcus njalensis Laing (see previous Quarterly Report) have developed symptoms, usually much milder than those of the West African Amelonado controls and often taking longer to appear. All symptomless plants were "back-tested" at 4 months old, using vectors: ten out of 131 have proved to be infected so far, though two of the ten have shown symptoms since testing. Final results from the "back-tests" are not yet available, but it seems probable that some of the Iquitos progenies are more resistant to infection, at least as beans, than West African Amelonado. An alternative though rather unlikely explanation of the results is that some of the symptomless Iquitos plants are infected, but contain too little available virus for it to be detected by our standard back-testing technique.

A modified method of testing for resistance has been applied to material received from the Plant Breeders since September 4th. All beans from each pod are planted intact in boxes of sand, along with Amelonado controls. The resulting seedlings are then "twinned", as described by Posnette (Trop. Agric., Trin. 19, p.146), and replanted singly in baskets; provided replanting is done immediately after separation there are few casualties. One plant in each pair is "bombarded" at about 3 months old with 150 infective "crawlers" of P. njalensis. In later stages the procedure will be substantially the same as before. The modification will ensure the availability for further testing of virus-free material of promising lines. Twin plants should also be particularly suitable for observations on tolerance, a useful characteristic only if associated with a high degree of resistance to infection.

2. MEALYBUG STUDIES

(a) Movement of Mealybugs in and between Standing Trees

Experiments under this head are still devoted to the development of suitable techniques for labelling the insects. A technique for radioactivating trees with ^{32}P by trunk implantation has been devised and, while this has been successful, further refinements are still necessary.

(b) Effect of Wind Currents on Mealybug Dispersal

Mealybugs continue to be recorded on seedling traps on the W.A.C.R.I. Reservoir. Sticky traps have been abandoned in this experiment because of the very few insects captured. Adhesive traps continue to be used in the study of the aerial movement of mealybugs from ground level to above the cacao canopy. Similar traps are also being employed to investigate the aerial movement of vectors along

roads .../

roads. Preliminary results have been obtained in studies of the effect of forest trees on the deposition of mealybugs carried by wind. Further work is necessary before any definite conclusions may be reached.

(c) Seasonal Variation in Mealybug Populations

Observations are continuing on mealybug populations and their associated predators, parasites and ant attendants in different types of habitat.

(d) Biological Control of Mealybugs

A total of 92,510 parasites, made up as under, has been liberated in the Old Station during the quarter:-

46,820 Pseudaphycus angelicus
41,580 P. Mundus
4,110 Anagyrus pseudococci

During the period 58 emergents have been obtained from P. njalensis collected from four release areas. These have been submitted for identification.

3. STUDIES OF BLACK POD DISEASE

(a) Fungicide Control Trials

Corresponding results to those given in the last Quarterly Report are summarized below for the present quarter:-

TRIAL I

Treatment	PODS PER TREE			
	Total	Damaged	'Black-Pods'	Otherwise Damaged
Control (unsprayed)	13.77	5.86	2.96	2.90
'Carbide-Bordeaux'	14.41	5.00	2.41	2.59
Bordeaux Mixture	15.01	7.16	3.01	4.15
Perenox	16.35	7.10	3.31	3.79

TRIAL II

Treatment	PODS PER TREE			
	Total	Damaged	'Black-Pods'	Otherwise Damaged
Control (unsprayed)	19.30	5.28	3.37	1.91
Perenox	19.17	4.59	2.07	2.52
Blitox	15.68	4.14	2.79	1.35

No treatment has effected any control of Black Pod disease in the two trials. Possible reasons for this lack of

control .../

control are being investigated.

There is no reason to suppose that the components of the two types of Bordeaux Mixture have deteriorated, and our stocks of the two proprietary fungicides - Blitox and Perenox - have proved to be up to specification in analytical tests carried out by the makers. Improved spraying lances and nozzles giving a more efficient "cover" of fungicide to the pods have been tested.

(b) Spore Dispersal

A spore trap has been operated in an area heavily infected with black pod disease for twenty-four-hour periods once each week when possible. No spores of Phytophthora palmivora have yet been detected.

(d) Utilisation of Beans from Diseased Pods

Acknowledgement is due to Takoradi Mills, Limited for processing a 2½-ton quantity of beans from black pods and for submitting the following analytical report:

"Whole Bean

Fat	-	45.12%
Moisture	-	7.20%
Free Fatty Acid	-	17.00%

Butter. Samples from the expellers, filtered in the laboratory:

Free Fatty Acid	-	17.4%

Butter. Expelled, filtered (filter press) and deodorized:

Free Fatty Acid	-	7.5%
Unsaponifiable matter		0.9%

Kreiss-Kerr test for rancidity - Negative

Taste - Poor, Strong after taste.

Smell - Poor

Colour - Red brown (appearance of normal solvent extracted butter).

Defatted Cake

Fat	-	0.57%
Moisture	-	14.71%
Theobromine (on dry fat free)	-	1.14%"

4. CAPSID STUDIES

(b) Protection of Young Bearing Trees

The large scale trial at Nankese Sub-station continues in a modified form.

Much of the treated areas have now grown beyond spray-painting. The latter is continuing where feasible whereas the areas which have grown beyond it are now treated

by .../

by mist-blowing using the Kiekens-Dekker machine and 5 per cent. DDT or 0.2 per cent. gamma B.H.C. and aqueous emulsions.

The experiment to assess possible damage to cacao by DDT emulsions continues. Indications are that, below 2.5 per cent. DDT, damage by spray-painting is negligible.

(f) Capsid Population Studies

In the Tafo area the populations of both D. theobroma and S. singularis attained their peaks during the latter part of September. Since that time the population of S. singularis has shown a continuous decline. The population of D. theobroma also fell during October and November but has shown an increase during the first half of this month.

Twelve months records have now been obtained by this Routine Collection method of sampling the capsid population. An examination of these data in conjunction with the meteorological records collected at the Institute has indicated that a relationship exists between the numbers of capsids and the saturation deficit during the preceding six to eight weeks. A highly significant negative correlation has also been found between the population estimate and the total hours sunshine during the preceding month. While this may be a direct effect of temperature, it is also possible that it is associated with the actinic activity of the sun.

A preliminary examination of the population estimates and meteorological data obtained within small plots within the cacao has not shown the relationships mentioned above. This may be partly explained by the considerable variation in the successive intensive fortnightly counts of the capsid population. However, the relationships may become clearer when records for a complete annual cycle will have been obtained in March, 1955.

Combined Cultural and Insecticidal Control

The treatments in the Dusting and Pruning experiment commenced last June on four-year-old Amelonado cacao have continued. It is not considered necessary to carry out an analysis of the fortnightly records of damage, capsid counts etc. until after the end of the next quarter. However, it is interesting to note that the trees in the plots which are under the pruning treatment are showing signs of quicker canopy formation because successive flushes are appearing as laterally directed fan branches, whereas in the unpruned plots new growth is occurring mainly as chupons.

The fortnightly treatments consisting of a localised insecticidal dust application to trees on which capsids or recent damage is seen, were carried out regularly during the period. An average of 7 trees per acre required dusting at each treatment.

Labour requirements -

Inspection, removal of chupons and damaged shoots ... 14 man hours/acre/month

Dusting .../

Dusting operation ... 1.5 man hours/acre/month
Quantity of dust used (5% DDT) 1.5 lbs./acre/month.

5. EXPERIMENTS ON ESTABLISHMENT AND MAINTENANCE

(a) Establishment Trials

Experiments on transplanting methods show that seedling nurseries should be established on sandy or other easily-worked soil. The seedlings should be lifted with a fork with as little root damage as possible. The optimum age for transplanting is about four months. Reduction of foliage is unnecessary.

(b) Spacing Trials

Widely-spaced Amelonado cacao is found to be much more susceptible to capsid injury than are closely spaced plants. A minimum density of 900 trees per acre is necessary if serious injury is to be avoided in the early years of growth.

In the case of Upper Amazon selections, establishment has been good at all spacings between 8 x 8 feet and 12 x 12 feet.

(c) Shade Trials and Observations.

Regeneration of permanent shade in established cacao has been successful only where the cacao canopy itself was discontinuous. It is evident that most of the species used as shade cannot develop except in well illuminated conditions. No difficulty was experienced, however, in establishing seventy species of shade tree in the open.

(d) Seedlings versus Rooted Cuttings

Unexpected difficulties have been encountered in the establishment of fan cuttings in the Seedling vs. Cutting experiment planted in June of this year. Losses of cuttings have reached the high level of 28 per cent. already against only 2 per cent. for seedlings under identical conditions. In addition, losses in the recently planted Pruning of Cuttings experiment are now 10 per cent. It is therefore intended that establishment experiments for clonal material should be carried out as soon as practicable.

(e) Effect of Soil Type on Pod Development and Yield

Data accumulated over four years are now almost complete. Casual scrutiny of the figures suggests that the yields obtained on the various soil types represented at WACRI are not markedly different.

6. SOIL FERTILITY AND MANURIAL EXPERIMENTS

(a) Experiments on the Effect of Major Nutrients

Growth measurements have been taken on the fertilizer trials on Amelonado seedlings. Whilst growth on all sites except Goaso has been indifferent or poor, no striking responses to fertilizers have been obtained. No new field NPK trials on seedlings are to be started until some reasons for this lack of response in the existing trials

have .../

have been discovered.

Leaf samples have been taken from the trials at W.A.C.R.I. and Bunso and will be analysed for major nutrients. Preliminary results indicate that, on one trial at W.A.C.R.I., there has been no absorption of fertilizer nitrogen.

An experiment has been started to find out under what conditions seedlings respond to fertilizers in pots. It is thought that if responses are not obtained in pots, they are unlikely to occur in the field. The pot trial referred to in the January-March report has been harvested. As a number of seedlings had been killed by insects, a full analysis has not been attempted, but two significant effects were obtained:

(i) a 27 per cent. increase in fresh weight of tops by sulphate of ammonia.

(ii) a 20 per cent. depression of fresh weight of tops by muriate of potash, but no depression by an equivalent amount of sulphate of potash.

It was as a result of early visual symptoms in this experiment that sulphate of potash was substituted for muriate in the field trials. This change has been fully justified by the final results.

A pot trial has been started to compare the performance of Amelonado seedlings growing in soils from the control plots of the field trials at W.A.C.R.I., Oyoko and Goaso. The object is to see whether the great differences in the field performance of cacao at these sites are maintained when the different soils are put in the same environment.

(g) Role of Minor Elements

Zinc deficiency has been noticed in many cacao trees throughout the station. Spot plans were prepared for recorded trees and there was an indication that the zinc deficiency was depressing yield. The deficiency nearly always occurs near rotting tree stumps or logs.

An experiment has been laid down to test the effect of zinc deficiency on yield. The deficiency is being induced by spreading wood shavings around the trees.

7. ROOT STUDIES

(b) Distribution of Roots

A study of the roots of a mature cacao tree in an area of marginal cacao in Ashanti was carried out. The soil had a thin humus layer, about 4 feet of uniform clay-loam, then a hard bed of sandstone. The tap root extended down to the sandstone then continued horizontally for about 10 feet giving a total length for tap root of 14 feet. This is much longer than has been seen to date for cacao. The lateral roots were few and entirely confined to the top 6 inches of humus.

8. VEGETATIVE PROPAGATION

(a) Simplified Methods for Production of Rooted Cuttings

Stock-Scion Influence in Budded Plants

The stock cuttings have been rooted and hardened and will be budded as soon as suitable.

Routine Propagation. Propagating Unit

The roof of the propagating unit had been largely rebuilt and the main portion has been lowered to a height of seven six inches to encourage a still humid atmosphere around the propagating bins.

Clonal Nursery

In spite of routine spraying considerable capsid damage has occurred amongst the plants. The nursery is now under constant inspection and any plants showing damage are dusted with DDT.

Field Propagation

The wooden frames on nursery beds have continued to produce satisfactory results. 50-60 per cent. of hardened plants appears to be an average performance.

Routine Production of Cuttings

Considerable numbers of cuttings are being produced for the Plant Breeders, Agronomist and Pathologist.

Flushing Behaviour. Effect of Light Treatments

As reported previously continuous light treatment of clonal plants caused initial defoliation and then profuse bud proliferation, whilst an eight-hour day caused defoliation but little bud proliferation.

As these effects could have well been conditioned by the previous history of the plants, a further experiment was laid down in which seedlings were used which had been germinated under the respective light conditions. After potting the positions of the pots were interchanged daily during daylight hours to avoid block effects.

The leaf products and heights were measured when the second flush had hardened. There were no differences between the mean leaf products per plant but those receiving continuous light had a mean height two centimetres greater than those under an eight-hour day. The observations are being continued.

Apical Bud and Leaf Removal

Apical buds and varying numbers of leaves at different positions, on clonal chupon plants which had not jorquetted, were removed to ascertain their effect on auxiliary bud proliferation. So far there has been no bud proliferation.

9. PLANT BREEDING AND SELECTION

(a) Progeny and Introductions Trials

(b) Breeding Work

(c) Growth and Yield Trials

The crop from all trial areas has decreased during the quarter and has not reached the level of September.

(e) Inter-specific Crosses

(g) Incompatibility in Cacao

(h) Genetics and Morphology of Hereditary Characters

(i) Production and Study of Polyploidy

Continued poor flowering has slowed the progress of several cytogenetical studies although some improvement was noted towards the end of the quarter.

Polyploid studies continue.

10. CACAO FERMENTATION AND QUALITY

In the absence of a Chemist on the staff during the entire quarter, much of the work on fermentation and quality has had to be suspended.

The development of a new method of fermenting small samples of cacao by Wadsworth and Howat (Nature, Vol.174, No.4426, 1954) and the new principles which appear to emerge in consequence, has enabled small samples produced by the Plant Breeders to be prepared for quality appraisal. An attempt has also been made to employ these principles in bulk fermentations, especially by temperature control at critical stages of the fermentation process. Some difficulty has been experienced in the assembly of apparatus for this purpose and the results obtained so far are of little value.

The selection T10 has been excluded from the list of acceptable Upper Amazon types by the Cocoa, Chocolate and Confectionery Alliance Limited on account of small bean size. Further bulk fermentations have been carried out with this selection to see if there is any improvement in size with increasing age of the tree. No such improvement has taken place.

11. PINHOLE BORER INVESTIGATIONS

It has not been possible to commence work on this problem as, at the time of writing, no outbreaks have been reported in the Gold Coast this season.

12. INSECTICIDE STUDIES

Monthly inspections continue on the Atukrom experimental plot which has been repeatedly treated with "Hanane" to detect a possible effect on the rate of virus spread. This work is carried out in co-operation with Pest Control Limited and the Department of Agriculture. Diseased trees are cut out and mealybug counts are made on such trees.

The .../

The experiment, in conjunction with Messrs. Pest Control Limited to confirm, using the trunk injection method of application, whether second or subsequent doses of "Hanane" are in fact absorbed, has been completed. Resort was had to artificial re-infestation and this was carried out 4 weeks after second treatment. Two weeks later mealybugs were established on three out of five trees.

13. ARBORICIDES

Work on arboricides is drawing to a close and a comprehensive report is to be issued in the near future.

14. CHERELLE WILT

As mentioned in the report for the last quarter, two types of cherelle wilt are now known to occur. It has since been shown that 'First' wilt passes its peak as cell walls are laid down in the endosperm and that 'Second' wilt ceases as embryo metabolism increases rapidly and fat and starch begin to be manufactured.

Alcoholic extracts of ovules have been tested for growth substances. While no substances have been identified differences have been found between healthy and wilted pods.

Tryptophane, an amino-acid which is a precursor of indole-acetic acid, a plant hormone, has been found to be deficient in ovules from wilted pods, suggesting a deficiency of the hormone.

The results of the season's hand-pollinations show that the percentage wilt on comparable trees is variable. There seems to be little difference between selections as regards liability to wilt.

The 50 10-year-old Amelonado trees which have been studied weekly for wilting have turned out to be very poor yielders. During 1954, 1,330 pods were formed and only 35 reached maturity, of which 6 succumbed to black pod disease; giving a percentage wilt of 97.

INVESTIGATION OF CACAO "SHADE"

Several aspects of the work of the quarter have emphasised the necessity for elucidating the function and mode of operation of shade trees in cacao cultivation and experiments and observations on this problem have been commenced. The problem will be assigned a place in the Research Programme for 1955-56. The following is a summary of the work in progress.

(a) Effect of Shade, Mulch and Nitrogen on Seedling Establishment

An experiment has been laid down in the clonal nursery in which seeds were sown singly at stake, at four feet square spacing, under three conditions of shade:

1. No shade
2. Shaded by cut palm fronds
3. Shaded by tree cassava and gliricidia.

All plants are being watered.

Thirty-plant .../

Thirty-plant plots were selected in each set of condition one plot selected at random under each shade type when the first flush was hardened; received one of the following treatments:-

(i) Organic mulch

(ii) Sand - to give the soil protection of organic mulch without the nutrient effect

(iii) No mulch

These three treatments were used with:

(iv) No added nitrogen

(v) Nitrogen given as sulphate of ammonia at monthly intervals and watered in.

Growth measurements are being made.

(b) Effect of Day Length and Fertiliser Treatment on Growth Response

Plants were sown singly in concrete pots under four sets of day length conditions:-

1. 4-hour day - 0800 - 1200 hr.
2. 4-hour day - 1200 - 1600 "
3. 8-hour day - 0800 - 1600 "
4. Normal twelve-hour day.

The day length changes have been achieved by the use of wooden frames covered with aluminium sheets. Initial temperature recordings were made inside and outside the frames and it was found that there was only a diurnal fluctuation of 6°C. under the frames. The external temperatures were higher during the day and lower at night. The points of intersection of the two curves, inside and outside temperatures, were at approximately 0800 and 1600 hrs. For this reason all plants will be shaded at night to ensure uniform night temperature.

Plants within each day length treatment will receive N, P and K starting from the hardening of the first flush.

(c) The effect of forest litter removal upon the growth of Amelonado seedlings.

(d) A pot fertilizer trial on seedlings growing without shade.

(e) Soil moisture determination on shaded and unshaded plots of the 1st P.T.A.

IBADAN SUB-STATION

1. VIRUS RESEARCH

(a) Host Range Investigations

The search for naturally infected Adansonia digitata trees has been extended to the Iseyin and Ogbomosho areas and it is planned to increase the scale of the survey as the mealybug supply improves.

(c) Virus Classification

Incubation Period of Nigerian Viruses

In an experiment on the incubation period of Offa Igbo isolate when transmitted by insects to trees, symptoms have developed in one tree 47 days after the first infestation and in six other trees after 62 days.

Symptoms

Nigerian CSSV has previously been considered to be mild in its effects on cacao, but one isolate from the area where CSSV was first found in Nigeria is now known to cause defoliation and death of seedlings infected in the bean stage and grown in the insectary.

Some differences have been noted in symptom pattern produced by the 10 isolates under observation. Particularly with those having severe effects, great differences in symtpom expression have been found to occur between seedlings infected with the same isolate, probably reflecting genetic differences.

Rate of Spread

Symptom recording has continued at the Offa Igbo Observation Plot and the latest list of results is given below:

TABLE I

Month	Total No. of Trees Alive	No. Infected	New Infections	Healthy / Infected x 100	No. Flushing
Sept.	296	17	-	5.7	
Oct.	295	30	13	10.7	
Nov.	292	39	9	14.7	
Dec.	291	50	11	19.7	
Jan.	289	55	5	22.8	
Feb.	289	64	9	27.3	
March	288	78	14	34.6	
April	287	95	17	45.2	
May	287	109	14	55.0	
June	285	122	13	68.5	47
July	284	131	9	74.8	73
Aug.	284	135	4	85.6	24
Sept.	284	145	10	90.6	79
Oct.	284	158	13	104.3	188
Nov.	284	172	14	125	173

Five .../

Five trees, patch-grafts from which infected seedlings in January 1954, have never shown symptoms over the period of 14 months observations. They are being retested for infection. Fourteen apparently successful grafts from trees bearing symptoms in December 1953 have so far produced no symptoms in the test seedlings.

Yield records of all trees in the Offa Igbo and Koroboto Observation Plots have been continued.

Coppicing Experiments

Six CSSV outbreaks have now been coppiced jointly by the Sub-station and the Cacao Survey Division. Many more outbreaks have been coppiced by Cacao Survey Division in the course of experiments on CSSV control. Data on the success of regeneration and the appearance of symptoms on chupons is being collected from all the coppiced areas.

Further observations on the coppicing experiment at INA, reported in the last Quarterly Report, showed that the time required for chupon production after coppicing varied with tree-girth, but there was no difference in the ability of the stumps in different girth categories to produce chupons (Table II).

TABLE II

PERCENTAGE REGENERATION IN RELATION TO GIRTH AT VARICUS INTERVALS AFTER COPPICING I.N.A. CACAO FARM 1954.

Girth Category	Period After Coppicing in Days									
	54	63	70	76	83	108	112	120	126	140
0"-4"	76	82	82	88	88	88	88	88	88	88
5"-8"	64	84	84	87	89	89	89	89	89	89
9"-12"	58	77	83	83	83	85	85	87	87	87
13"-16"	54	57	70	75	82	82	82	82	82	84
17"-20"	36	56	61	61	64	79	83	87	87	87
21"-24"	27	45	49	51	55	65	71	71	71	71

Further experiments have been started at INA farm to find out the effects on regeneration after coppicing of a number of factors, including girth, coppicing height, condition of trees, capsid damage, shade, flushing status, soil water content, time of year, temperature and humidity.

2. MEALYBUG STUDIES

(d) Biological Control : Nigerian Survey

Natural Enemies of Mealybugs

Two mealybug parasites new to the W.A.C.R.I. collection have been reared during the quarter. One is a species of Anagyrus and the other a Pseudaphycus sp.

Both .../

Both are "social" parasites, i.e. more than one individual may emerge from a single host specimen. The former was reared from Pseudococcus sp.nr. gahani Green and is the second species of Anagyrus in which the "social" habit has been observed. The Pseudaphycus has been reared on two occasions from Planococcus kenyae (Le.P).

A coccinellid beetle (Hyperaspis sp.) was reared from a larva preying on Dysmicoccus sp.nr. brevipes (Ckll.) on roots of Gomphrena globosa several inches below the surface of the soil. This beetle was previously represented in the W.A.C.R.I. collection by only two specimens, both of which were found at rest on plants without associated prey.

Small red nymphal mites have been found as ectoparasites on Planococcus citri, P.kenyae, Pseudococcus bukobensis, P.njalensis, and Ferrisiana virgata in two localities.

A large collection of parasites and predators is being prepared for dispatch to taxonomists in the United Kingdom. Over 100 hymenoptera, parasitic on mealybugs and scales, and on their predators, are now ready to send off. The collection of Coccinellids is being sorted.

Mealybug Population Studies

The figures from the whole trees examined at I.N.A. in July have been studied and it appears that considerable differences occur between the make up of the mealybug population examinable from ground level, which in this case contained 40 per cent. of P.citri, and that on the rest of the tree, where P.njalensis was dominant. Differences were also noted in the average size of colonies occurring at the two levels and in the mean colony size for various species.

As the data obtained appeared to take a definite form, but to be of a type which did not lend themselves to simple statistical treatment, they have submitted for examination and advice.

Mealybug Cultures

Pure cultures of P.kenyae and P.citri have been successfully established on cacao seedlings and are building up rapidly. Lack of insectary space has prevented any attempts to culture other species, except for two root infesting forms, Geococcus coffeae and Dysmicoccus sp.nr. brevipes, which were put onto the roots of cacao seedlings in root observation boxes. The former species multiplied readily and has been used for vector studies, in which it did not transmit CSSV. The latter failed to establish itself either on cacao, or on its best known host plant, Gomphrena globosa, when grown in a similar box. Further attempts will be made to culture this species if more material can be found.

Collecting .../

Collecting of Root Infesting Mealybugs

A repetition of the trials with the Berlese funnel reported in last quarter's report gave similar results. Geococcus coffeae again proved easier to recover than did Dysmicoccus brevipes.

No mealybugs were obtained from samples of soil taken from cacao farms. With the onset of the dry season supplies of D. brevipes from canna roots have been difficult to obtain, but this may well be a coincidence and not due to seasonal variation.

AAB